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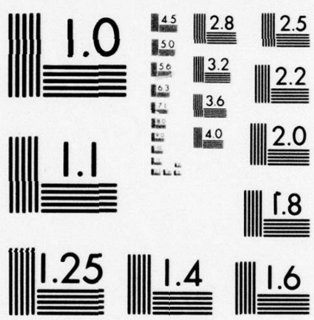

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Technical Note 1-78

HEL PARTICIPATION IN THE PLAN FOR ASSISTING IN THE DEFINITION OF ARMY HELICOPTER ELECTRO-OPTICAL SYMBOLOGY: AN INTERIM REPORT

Andrew T. Buckler

June 1978
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U. S. ARMY HUMAN ENGINEERING LABORATORY

Aberdeen Proving Ground, Maryland

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This is an interim report on progress made thus far toward optimization of symbology for electro-optical flight displays in Army aircraft. The Army aviation community adopted a plan in late 1977 aimed at determining standardization requirements and optimal symbology formats. At this time, a literature review, a task analysis and trade-off analysis have been completed while a time-line analysis, information conflict identification, an analysis of flight modes and evaluation criteria development are all in progress. This report provides a summary of the program tasks listed above as well as a review of concurrent efforts toward defining symbology for the pilot night vision system in the Advanced Attack Helicopter.

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12 52p.

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HEL PARTICIPATION IN THE PLAN FOR ASSISTING IN THE DEFINITION OF ARMY HELICOPTER ELECTRO-OPTICAL SYMBOLOGY: AN INTERIM REPORT

INTRODUCTION

The requirement for night operation of Army helicopters led to the development of night vision systems and the use of electro-optical displays in the modern cockpit. The use of these displays provide an opportunity to integrate a significant amount of flight information into a single display. Care must be taken, however, to assure that the pilot will not be overburdened by the increased workload associated with these new developments.

The first Army aircraft to make use of this new technology will be the Advanced Attack Helicopter (AAH) which will be equipped with a Pilot Night Vision System (PNVS). The PNVS will present a forward looking infrared (FLIR) image on a helmet-mounted cathode ray tube display. Overlaid on this video image will be primary flight information in symbolic form. This system will allow an increased capability for pilotage as well as target acquisition during both day and night operations. This increased capability will be largely dependent on what information is portrayed as well as the format of the symbology appearing on the display.

The Army aviation community has recognized the criticality of flight symbology in the successful use of the PNVS and future electro-optical flight display systems. To ensure that the correct information is provided and transferred in the most effective manner, involved Army agencies and activities have developed a Plan for Assisting in the Definition of Army Helicopters Electro-Optical Symbology (see Appendix A). The overall objective of this plan was to establish information requirements and symbology formats for use in the AAH and future aircraft, such as the Advanced Scout Helicopter, in a timely and systematic manner.

The plan was developed in November 1977. The purpose of this report is to report on the progress that has been accomplished in meeting the objectives of the plan. To do this, a chronological history of the meetings and activities will be reviewed.

DISCUSSION

The first meeting was held at the US Army Human Engineering Laboratory (HEL), Aberdeen, MD, on 11-12 October, 1977, to focus on symbology issues. The minutes of this meeting are inclosed in Appendix B. The attendees at that meeting agreed that a coordinated Army effort would be required to develop symbology which will effectively present the information required.

A second meeting was hosted by the Avionics Research and Development Activity (AVRADA), Fort Monmouth, NJ, on 15-16 November, 1977. The first day of the meeting was devoted to a discussion of AAH contractor symbology efforts as well as presentations by AAH Project Manager Office, AAH TRADOC Systems Manager and HEL. A discussion and demonstration of the AVRADA simulation and flight validation facilities were also included. The second day of the meeting was devoted to an ad hoc committee which developed the draft symbology plan included in Appendix A.

The plan itself includes 13 program tasks to be completed by various Army agencies and activities toward accomplishing the objectives of the plan. At this time, five of those tasks have been completed. Concurrently, baseline symbology formats have been developed and refined by the AAH contractor and the Army. After a review of the program tasks, focus will shift to a discussion of the evolution of the baseline symbology.

The first task called for a review of the literature related to helicopter electro-optical flight symbology focusing on experimental work comparing various symbology formats. This review was conducted and published by HEL in February 1978 (1). The results of this review showed that very little work has been done in this area except that done by AVRADA. This research focused primarily on defining information requirements for precision hover operations.

The second task required a task list analysis to be provided by the user and to be used in determining information requirements in the various mission segments. The task list is inclosed in Appendix C. A summary table of information requirements is shown in Table 1. A time line analysis was to be provided as the third program task to place the information requirements in the time domain across AAH mission segments. This task has not been completed at this time. Information conflicts were to be identified as Task 4 based on the requirements established in Tasks 2 and 3. This task has been delayed pending completion of Task 3.

Based on the information available, HEL conducted a modified version of the trade-off analysis required by Task 5, included as Appendix D. The purpose of this analysis was to identify the primary symbology issues and to summarize the trade-offs related to each.

At this time, the remaining program tasks still await completion. The two remaining tasks in the analytical phase, identification of the modes of display and criteria for evaluation have not been completed in a formal manner although work is progressing toward those ends.

Concurrent with the program tasks, work has been progressing toward defining baseline symbology formats. On 6 January 1978, the contractor submitted a first iteration of proposed PNVS symbology which is shown in Figure 1. A number of questions were raised by this Laboratory and others regarding this symbology. Some of the specific questions included:

1. The use of analog versus digital indicators for airspeed and altitude.

2. The need for a vertical speed indicator since this was not required by the user.

3. The adequacy of giving only hover position in the hover mode with no velocity or acceleration information.

4. The movement of the attitude indicator around the display with pilot head motions since attitude was tied to the aircraft line of sight (LOS).

5. The presentation of torque information only when exceeding or approaching some limit.

6. General concerns related to the wide field of view display, scale factors and the relationships between control and display dynamics.

During the week of 27 March 1978, contractor and Army representatives visited AVRADA and HEL. At AVRADA, the contractor personnel received a demonstration of the tactical avionics system simulator (TASS) which includes a video presentation of a terrain board. The

TABLE 1

Matrix of Information Requirements

	NIGHT				DAY			
	TRAVEL		HOVER		TRAVEL		HOVER	
	P	CP/G	P	CP/G	P	CP/G	P	CP/G
ANNUN CUE	X	X	X	X	X	X	X	X
THREAT WARN CUE	X	X	X	X	X	X	X	X
POWER STATUS	X		X		X		X	
IMPACT REF	X	X	X					
HEADING	X	X	X		X			
DOPPLER STEER	X				X			
AIRSPEED	X							
RADAR ALT	X		X					
ATTITUDE	X		?					
HOVER POS			X					
LAT & LONG VEL			X					
RNG TO TGT[a]	X	X	X					
MAG BRNG[a]		X		X		X		X
SOLVED RETICLE[a]	X		X		X		X	
UNSOLVED RETICLE[a]	X	X	X	X	X	X	X	X
PRE CONSTRAINTS[a]	X	X	X	X	X	X	X	X
POST CONSTRAINTS[a]	X	X	X	X	X	X	X	X
WEAPONS STATUS[a]	X	X	X	X	X	X	X	X

[a] Used only in weapons modes.

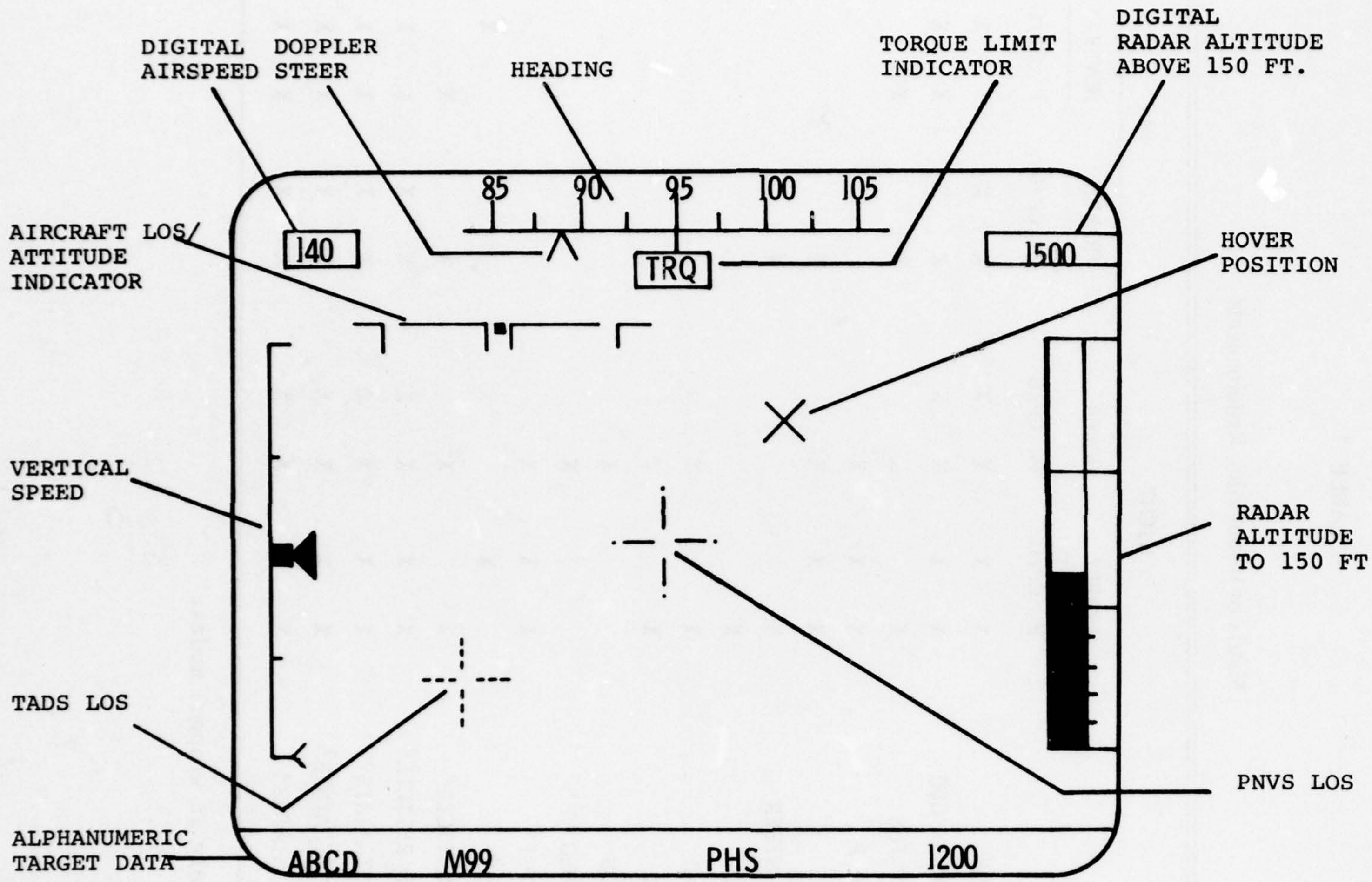

Figure 1. Symbology proposed by the AAH contractor in January 1978.

cruise mode symbology developed by AVRADA is shown in Figure 2. This symbology includes five modes—cruise, transition, hover, bob-up, and navigation. An extensive research effort by AVRADA, which included simulation and flight testing, showed that in order to maintain a precise hover, three bits of information are needed: a ground reference position, velocity and acceleration. (For a full explanation of these research findings, see Reference 2).

After the AVRADA demonstrations, the gathering was shifted to HEL where the symbology proposed by the contractor was simulated in the general aviation trainer (GAT) simulator. This demonstration highlighted some of the problems mentioned above. In addition, another symbology format was demonstrated which had been developed by HEL to contrast with the format proposed by the contractor. No assertion was made that this format, shown in Figure 3, was a final answer to the problem. It simply demonstrated the other alternatives to some of the questions being raised. For instance, it included a stationary attitude indicator and all analog indicators.

Having seen these demonstrations, the contractor agreed to rework their symbology proposals. A meeting was then held at Hughes Helicopters on 26-27 April 1978, between the contractor and the involved Army agencies. The purpose of this meeting was to define a baseline symbology to be programmed by the contractor on the AAH symbol generator for use in testing. Figures 4, 5 and 6 show this baseline symbology. This format contains three modes: cruise, transition and hover/bob-up. In the cruise mode (Figure 4), radar altitude is given in both analog and digital form. Rate of climb is provided as well as a continuous torque indicator. Airspeed is given only in digital form. Attitude is shown by the dashed horizon line which is referenced to the PNVS reticle at the center of the display. The turn-and-slip indicator was added at the request of one of the pilots present. The PNVS gimbal limits display is shown at all times to help orient the pilot to the aircraft' s LOS as well as that of target acquisition designation system (TADS).

In the transition mode shown in Figure 5, a velocity vector and acceleration indication are added. The transition mode is used at relatively low speeds between a hover and actual cruise speed, such as in terminal area operations. The hover/bob-up mode (Figure 6) adds a hover ground position reference and deletes the airspeed, altitude, and turn-and-slip indicators. The velocity and acceleration vectors in the transition and hover/bob-up modes are to be scaled by the factors recommended by AVRADA.

In addition, the contractor has proposed weapons symbology which consists of the rocket pylon constraints shown in Figure 6 and a large square which represents the HELLFIRE missile constraints. Both of these symbols appear as steering commands referenced to the center PNVS reticle. That is, the weapons are ready to be fired when the constraints are lined up over the center reticle.

The baseline symbology derived thus far is acknowledged to be just that: a baseline which will be modified and molded to produce a final symbology format. Many questions and issues remain which must be settled before defining symbology to be used in the AAH. Cooperative effort between the Army and the AAH contractor will be required to resolve these issues.

The following is a listing of some of the primary issues identified by HEL at this time. Others may also be raised by other agencies which are outside the expertise of this Laboratory.

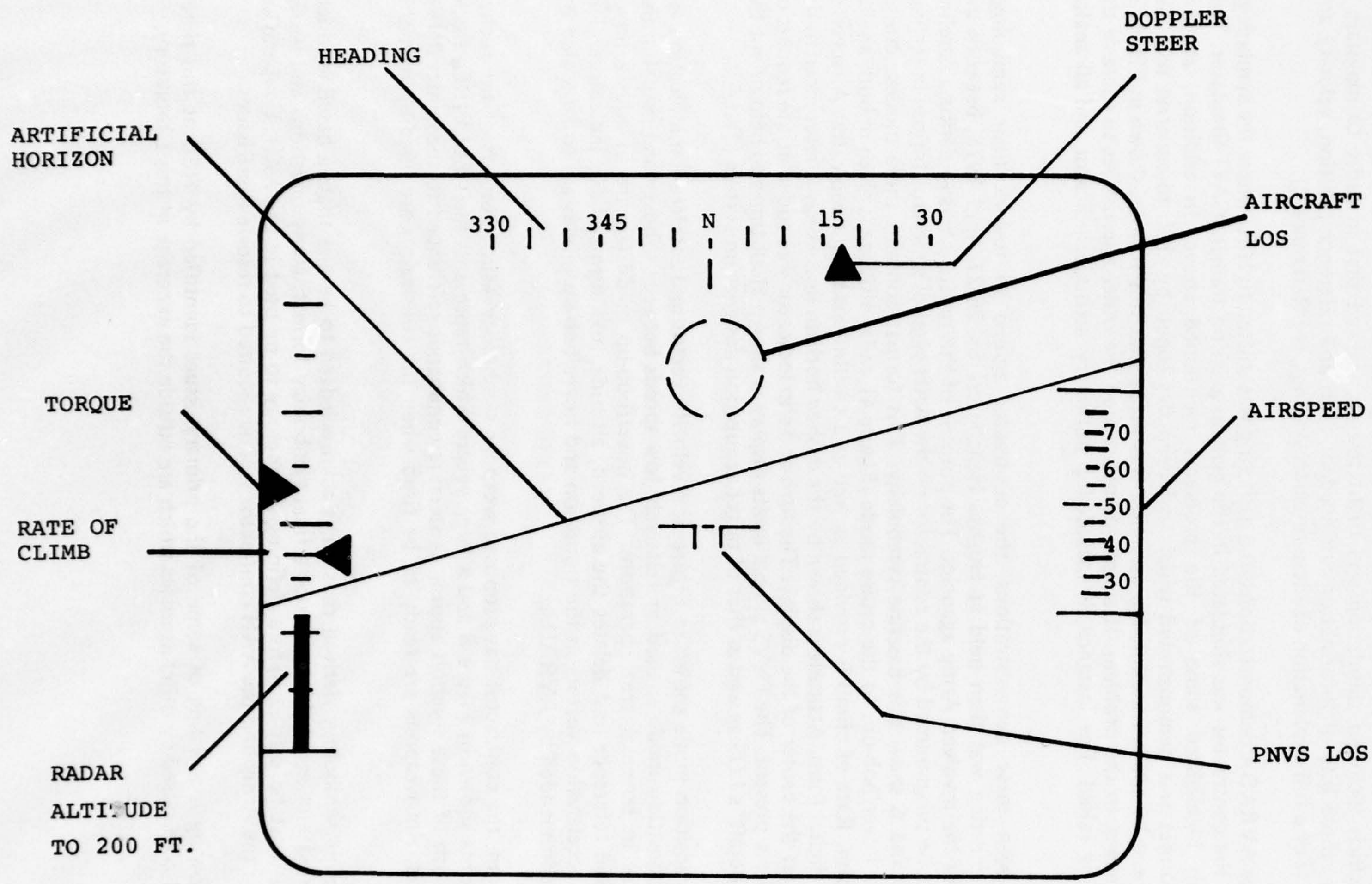

Figure 2. Cruise mode symbology developed by AVRADA (2).

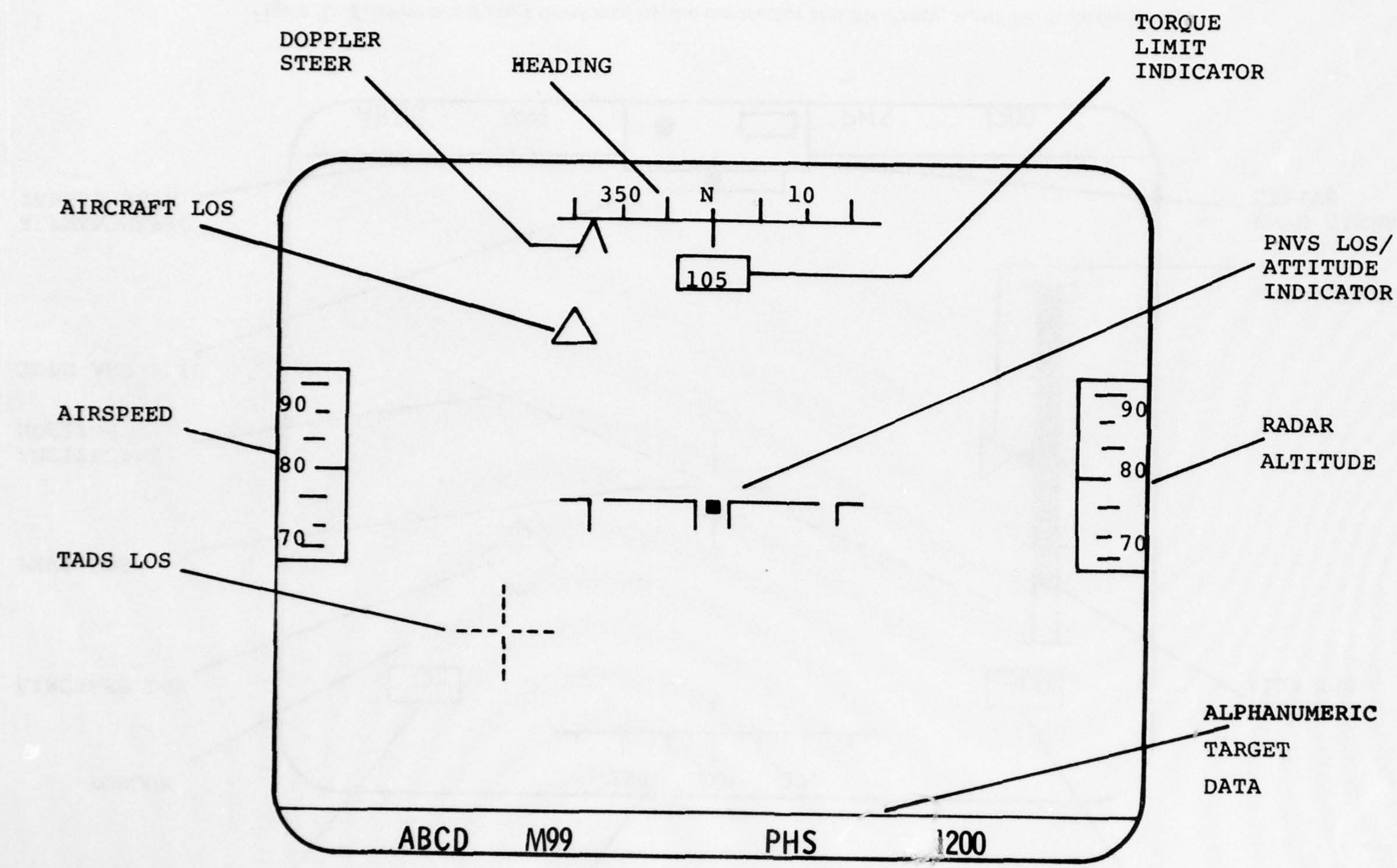

Figure 3. Symbology developed by HEL in March 1978 to contrast with the contractor's proposal.

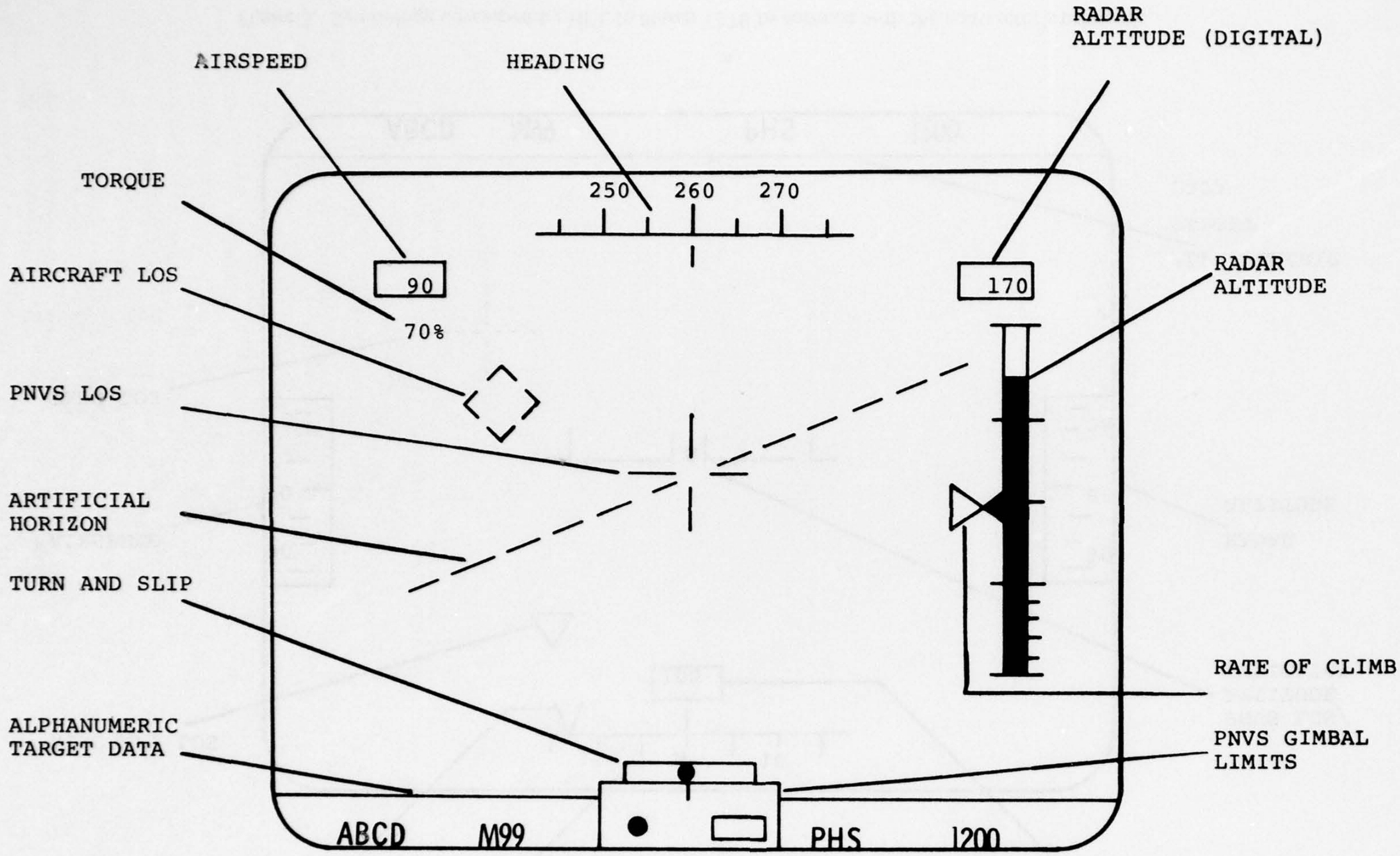

Figure 4. Baseline symbology developed by the contractor and the Army, April 1978; Cruise mode.

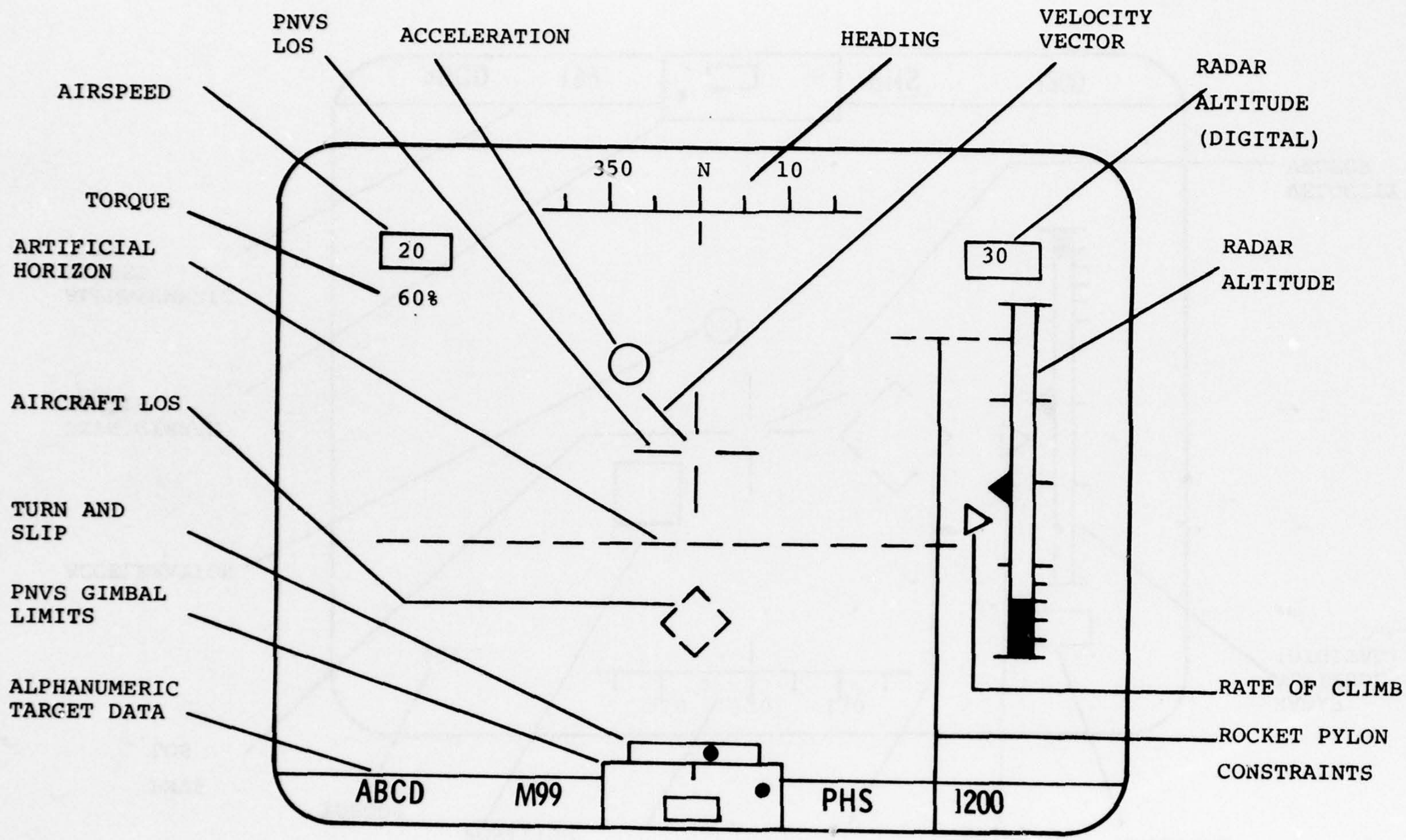

Figure 5. Baseline symbology; transition mode.

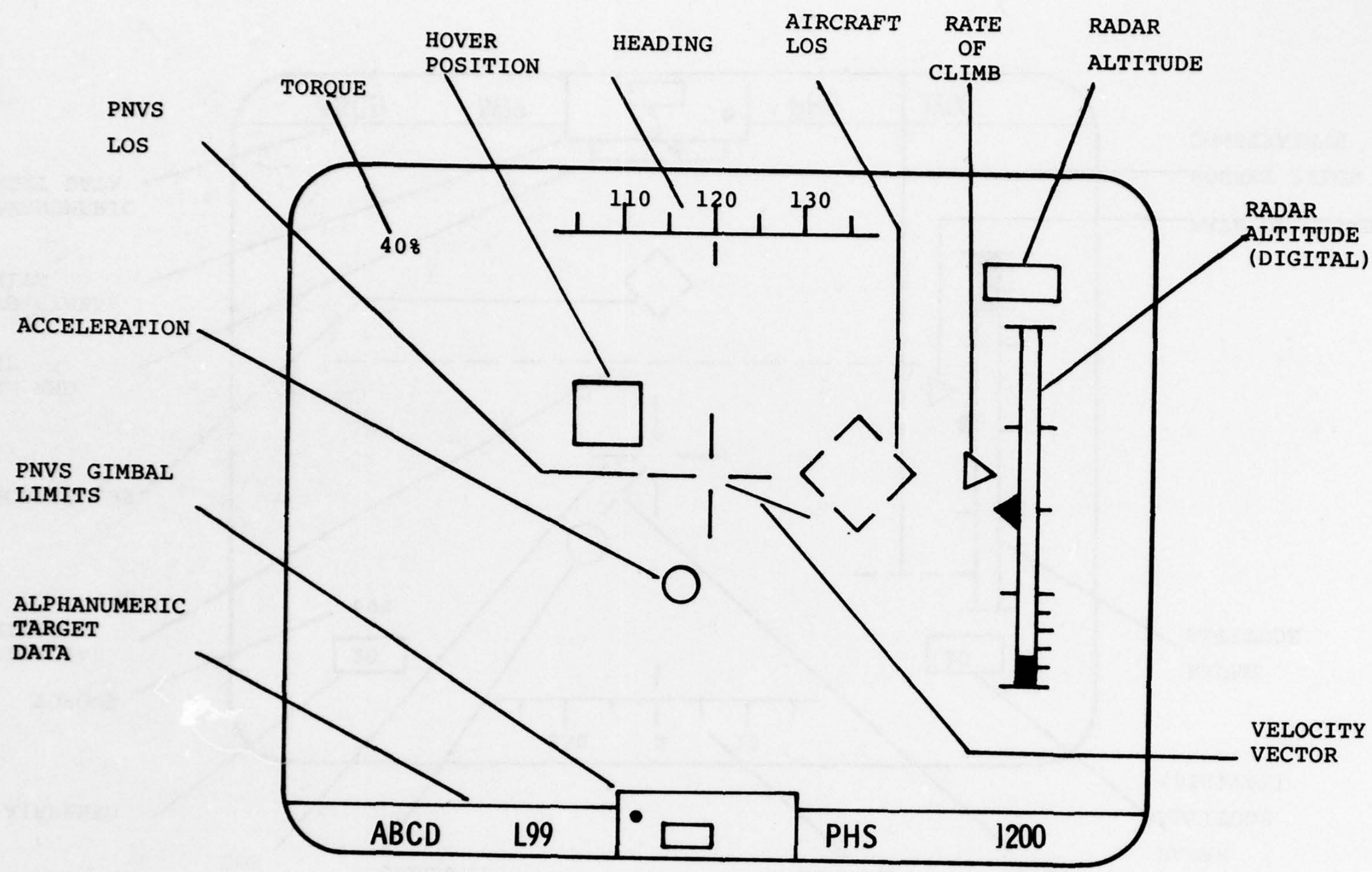

Figure 6. Baseline symbology; hover/bob-up mode.

1. Symbol Placement—According to MIL-STD-1472B,[1] the optimum cone of vision for eye rotation is approximately 30° in diameter. This means that a rather large portion of the 30° x 40° field of view (FOV) helmet-mounted display will be difficult to see, especially in the corners of the display. This would indicate that symbology should be placed near the center of the display to allow for easier visibility. However, placing symbology in the center of the display will significantly obscure the most important portion of the video image. A trade-off must be made between these two considerations.

2. Symbol Sizing—Characters and symbols must be large enough to be easily distinguished. However, if symbols are too large they will obscure the video image. Symbols should be kept as small as possible within the range of easy recognition and understanding. Testing should be performed to determine optimal sizing.

3. Scaling—Several factors should be taken into account in the scaling of moving symbols and changing scales. First, consideration must be given to the control dynamics of the aircraft so that control and display dynamics will be compatible. Second, the size of the display must be considered. On a 30° x 40° FOV, a symbol could have quite a wide range of motion which could cause eye scan problems. This should be taken into account when determining scale factors. Third, the rate of motion or change of symbols and indicators should be investigated. A symbol or indicator which changes too quickly or too slowly may be rendered useless.

4. Daytime Symbology—The information requirements for daytime flight must be established.

5. PNVS-EADI Compatibility—The Electronic Attitude and Directional Indicator (EADI) is a panel-mounted electro-optical display which will integrate essential flight information and be used whenever the helmet-mounted display is not used. It is imperative that compatibility be maintained between PNVS and EADI symbology. Constraints and limitations of the EADI display should be considered in deriving PNVS symbology.

6. Flight Modes—Mission scenarios and task analysis should be used to determine the modes of flight which are required. Consideration should be given to the information requirements of the various mission segments. However, care must be taken to avoid confusing the pilot with too many modes of flight. Determination of flight modes is Task 6 in the plan.

7. Indicator Design—Several methods are available for presenting numeric information such as heading, altitude, airspeed, etc. The relative advantages of digital, rolling scale and thermometer-type designs should be investigated for each indicator. The final determinations should be based on the use to which the information will eventually be put.

8. Video Image Obscuration—It must be remembered that many primary flight cues will come from the video image. Therefore, it is essential that every effort be made to avoid any obscuration of the image. However, in doing so, the pilot must not be denied any information he would need to effectively control the aircraft.

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[1] Department of Defense. Human engineering design criteria for military systems, equipment and facilities. MIL-STD-1472B, Washington, DC 20301, December 1974.

9. Information Requirements—As stated above, the pilot will be getting much of his primary flight information from the video image. AAH mission scenarios should be carefully studied to ascertain exactly what additional information must be supplied by the symbology. To avoid problems of overloading and video obscuration the information presented by the symbology should be only that which is necessary to successfully control the aircraft and accomplish the mission.

10. Fire Control and Steering Information—The present configuration provides symbolic steering information relative to the center of the display. This means that unless the pilot is looking straight ahead, the target designation on the symbology will have no relationship to what he sees on his video image. As a result, when firing 2.75-inch rockets or HELLFIRE missiles, the pilot will not know for sure where he is firing. This could present problems of crew coordination and could be especially troublesome when firing the rockets since these are launched by the pilot. Confusion could result since the pilot has been expected to rely heavily on his video image for primary flight information throughout the rest of his mission, and now he must disregard his video and rely entirely on his symbology. In addition, the video would still be used in firing the 30mm gun, and contribute even further to the confusion. Another source of concern is the fact that the center reticle will be representing the PNVS LOS and the aircraft LOS at the same time. The other option considered thus far tied the steering information to the aircraft LOS. This would make the target information compatible with the video image, but would create other problems. The most notable of these is that the symbology would move around the display as a result of movements of both the aircraft and the pilot's head. Compound the problem with a moving target, and considerable confusion could result. Trade-offs must be made between these methods of presenting fire control information while minimizing the problems which might arise from either.

11. Primary Source of Flight Cues—The problems stated above raise the more general question as to the relative importance of the video image and the symbology. The Army aviation community is divided on this question. Some say that the symbology will act only as a supplement to the video image, and that the mission using the PNVS will be flown under basically visual flight rules (VFR), almost like daytime flight. Others contend that the limitations of the PNVS and helmet-mounted display systems will force the pilot to fly instrument flight rules (IFR), and that the video image will act as a supplement to the symbology. This question must be resolved by the user and developing laboratories before symbology can be adequately defined. An IFR philosophy would imply a heavier emphasis on symbology at the expense of some video obscuration, while less symbology would be implied by a VFR philosophy.

12. Navigation—The information requirements and display formats necessary for navigation must be addressed in a systematic fashion.

13. Copilot/Gunner Displays—The symbology to be used on the copilot/gunner's displays must receive more attention than it has to date. The copilot will be primarily involved in navigation and target acquisition/designation, and thus his displays present special problems. In addition, he must have available the information necessary to fly the aircraft in case of incapacitation of the pilot.

The symbology plan calls for eventual simulation and flight testing of the proposed symbology formats. Some simulation has already been done by this Laboratory in demonstrating the formats proposed thus far. However, due to the limitations of the equipment, HEL is able to simulate only the symbology and not the video image.

Because of this limitation, HEL is unable to address the VFR-IFR controversy described above. It is the opinion of this Laboratory that until the questions regarding the interactions between the symbology and the video imagery are resolved, there is little more that can be done here on present equipment.

For this reason, a proposal was made by HEL to the TADS/PNVS Project Manager to design and conduct an experiment on a simulator which could examine these issues. After a survey of government and industry, it was found that the best simulation facility, based on capability and availability, for this task would be the one at Martin-Marietta Corporation in Orlando, FL. This facility provides a terrain board, a capability for programming of AAH flight dynamics and the ability to integrate a helmet-mounted display into the system.

The proposed simulation would provide the opportunity to test several different symbology formats and to observe their interactions with the video imagery. In addition, the initial group of AAH pilots could be given exposure to the system, and the experiment could be used as part of their training. By flying mock missions, a wide range of issues could be investigated including crew coordination and fire control.

CONCLUSIONS AND RECOMMENDATIONS

The symbology plan being pursued by the Army has thus far proved to be a useful tool in moving toward the objective of developing optimal symbology for electo-optical flight displays in Army helicopters. Much has already been learned as a result of the activities and analyses carried out under the plan. However, three of the greatest benefits of the plan up to this point are somwhat intangible. First, the plan has focused the attention of the Army aviation community on the importance of symbology in accomplishing the operational mission. Second, it has served to stimulate some hard analytical thinking about symbology issues by many members of the aviation community. Third, the plan has fostered new cooperation among the various Army agencies and activities who have participated in and contributed to the plan.

Up to this time, the program tasks and activities have been largely analytical in nature. "Paper and pencil" analysis was certainly required to provide a firm basis for entering into the next stage of the plan. The remaining program tasks call for definition of candidate symbology formats followed by dynamic simulation to evaluate the alternatives and select the best. This is to be followed by flight validation of the selected format.

The HEL fully supports this approach to resolving symbology issues and is eager to participate in this phase of the plan. However, at this point, the limitations of the equipment within the Laboratory prevent us from going into a full dynamic simulation. The interaction of video image with the symbology is expected to have a significant impact in the design of an optimal symbology format. Since the HEL has no facilities to provide such an image in flight simulation at this time, the simulation must be accomplished elsewhere.

A survey of both government and industry has shown that only two facilities are available which have the simulation capabilities required to meet objectives of the plan. One is the facility at Martin-Marietta Corporation in Orlando, Florida. The other is the Tactical Avionics System Simulator (TASS) at the Avionics Research and Development Activity (AVRADA) at Fort Monmouth, NJ. Although the advantages of using the Army's own in-house capability are clear, some problems have arisen as to the availability and utility of the TASS system for this purpose.

The HEL recommends that these two options be pursued to determine which is most advantageous to the government, and that after one is selected, preparations be initiated to begin such a simulation effort in the near future. The HEL proposal for a simulation effort at Martin-Marietta should be pursued if the TASS system is either unavailable or inadequate to the task. In the meantime, HEL will continue to provide support in the development of candidate symbology formats by simulation in the GAT simulator.

Accomplishment of the objectives of the symbology plan will require an intensive and cooperative effort by the various agencies and activities which make up the Army aviation community. Also, it is hoped that the AAH contractor would take an expanded role in the development of optimal symbology for the AAH. A sincere and devoted effort on the part of the Army and the contractor will be required to be sure that the issues and problems related to electro-optical flight symbology will be solved in a timely and effective manner to be responsive to the AAH as well as future Army helicopter programs.

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APPENDIX A

PLAN FOR ASSISTING IN THE DEFINITION OF ARMY HELICOPTER ELECTRO/OPTICAL SYMBOLOGY

PLAN FOR ASSISTING IN THE DEFINITION OF ARMY HELICOPTER ELECTRO/OPTICAL SYMBOLOGY

1. INTRODUCTION

a. The requirement to achieve 24-hour operation capability in current threat environments has precipitated the use of electro/optical (E/O) displays. These displays with their associated sensors, software, and symbology afford the Army aviator an increased capability for pilotage as well as acquiring and destroying targets during both night and day operations. However, this increase in capability will in part be dependent on not only what information is portrayed to the aviator on these displays, but how well it is portrayed. To ensure that the correct information is provided and is effectively transferred, three major objectives must be achieved. These objectives include: (1) defining in detail what information is required and when it must be available, (2) determining what combinations of sensors, software, imagery and symbology are needed to produce this information, and (3) establishing the format of the integrated symbology and imagery to assure efficient information transfer. These specifics form the baseline of the plan and are addressed in more detail under the objectives identified in Section 2 and the issues of Section 4.

b. The Army aviation community has long recognized the criticality of the above objectives and with the advent of the TADS/PNVS for the AAH and ASH, has realized the need for increased focus in this area to meet these objectives in a timely manner. To achieve this focus, involved Army agencies and activities reviewed the following sub-areas in regard to the current status of helicopter symbology:

(1) AAH crew information requirements.

(2) Ongoing technology base programs.

(3) AAH contractor efforts.

(4) Critical issues and problem areas.

c. As a result of this review, agreement was reached that further definition and clarity in this area was in the best interest of the Army. Therefore, this mutually derived plan was generated to achieve these goals. It was agreed that this plan would emphasize maximum support for the AAH as a short-term objective with the longer term goal being the establishment of standards for all helicopter E/O symbology. Towards the end, the plan identifies 13 specific tasks. For each task, one laboratory or activity accepted prime responsibility with volunteered support from other laboratories responsibility for coordination and finalization in written form the completed task accomplishments. All assignments were mutually derived of common consent and based on ongoing programs, expertise, equipment availability, and willingness to respond. The list of supporting activities was not considered to be all inclusive and additional support from other organizations is to be expected as the tasks are executed. The accomplishment of the 13 tasks was designed to:

(1) Be responsive to AAH requirements to meet current milestones.

(2) Incorporate ongoing and past Government and contract efforts.

(3) Integrate and coordinate activities and results in this area.

(4) Provide a basis for future efforts.

(5) Assist in gaining a data base with regard to specific uses.

2. OBJECTIVES:

a. The objectives of this program are:

(1) To formulate the basis for investigation and evaluation of Army rotary wing aviation electro/optical symbology and then,

(2) To establish firm, specific Army symbology requirements, generated from quantifiable data and current tactical doctrine, for standard and non-standard presentation, applicable to current and programmed aircraft systems.

(3) To provide criteria for future systems specification, development, and evaluation.

b. To meet these objectives, consideration of the information needs of the users for current, as well as future, tactical aircraft systems is essential. In addition, the symbology derived must be compatible with a variety of electro/optical display methods/means (i.e., head-up displays, helmet-mounted displays, and panel-mounted displays). These considerations shall remain paramount through the life cycle of this program.

c. While the final general objective is to construct standard symbolic requirements for all aircraft systems, the current driving force is to meet the immediate AAH, ASH, and AH-1 system requirements and finalize an Army standard as a basis for evaluating contractor proposed symbology.

3. CONSTRAINTS:

An Army standardization program for establishing the optimum symbology to be presented to the rotary wing aircraft crew is considerably limited by the following constraints which include:

(1) Funding and personnel support requirements must initially be provided within the scope of current allocations and ongoing programs.

(2) A delay in the proposed schedule of the symbology development plan could result if priority is not given to this program.

(3) The hardware and software to program and present recommended sets of symbology for development and evaluation may not be available on a timely basis.

(4) In order to be responsive to the ongoing AAH and AH-1 programs, the depth of total effort may be limited due to current program and time constraints. For example, the availability of the EVAR flight test aircraft is dependent upon the priority and schedule of current programs.

4. CURRENT ISSUES REGARDING SYMBOLOGY:

At least three general points of controversy remain to be resolved in order to derive a standard of E/O symbology. These issues are:

(1) The exact discrete bits of information a tactical aircrew must have available/selectable to accomplish any given tactical mission must be specified.

(2) This information must be transformed to symbology, which preserves the essential nature of the data, so that effective information transfer occurs in conjunction with video display.

(3) Engineering design must be able to derive methods to incorporate programming, which will accurately process sensor inputs and provide the desired information in the "standardized" symbols and format.

5. PROBLEM AREAS:

Various problem areas concerning the presentation of symbology, the exact symbols to be portrayed and other aspects which can influence and affect the final symbology selection will be a major concern during the entire process presented herein. These major problem areas and the definitions or explanations are as follows:

(1) Operating modes - selection of automatic vs manual.

(2) Clutter - Interference/interaction of symbology with the video scene; this is a function of location and quantity.

(3) Symbol density - The number of discrete information bits that can be interpreted rapidly and accurately at any given time and the multiple task demands represented by this density.

(4) Digital vs analog - The mode of presenting a bit of information to insure rapid and accurate interpretation. This will depend on the manner in which the operator responds to the information.

(5) Scaling - This determines the rate at which a symbolic representation of a source parameter changes or displaces for a given change in the parameter. It influences the accuracy as well as the rapidity with which the crew member can respond.

(6) Wide field of view displays - The integration of symbology with wide field of view displays creates a problem in positioning the symbology to reduce scan requirements without creating clutter.

(7) Effects of Video - Video scene brightness will have an effect on symbol readability. Conversely, symbols will influence video imagery where high relative brightness can mask critical video information.

(8) Effects of vibration on CRT or electro-luminescent displays—The refresh rate of the display interacts with vibration effects to cause perceptual problems.

(9) Compatibility between displays–This problem addresses symbology differences/standards among the various sensor uses of a given system, between systems and between different functional instruments/presentations.

6. PROGRAM TASKS:

The 13 program tasks with their focal points (marked with an asterisk) and supporting activities are listed below:

PHASE I. Analytical Phase Steps 1 - 7

(1) E/O Helicopter Symbology Review

This task will involve a review of current and past E/O symbology efforts which relate to helicopters. This review of programs and literature will provide an update of efforts in the area and assist in insuring that maximum utilization is made of previous efforts. A summary of the current, applicable data will be made from the review and provided to the concerned agencies/activities.

HEL*, PMO, AVIONICS, USER, NVL, USAARL

(2) Task List Analysis

This analysis will take the AAH task list provided by the user and further reduce it to elements which will provide a basis for determining in final detail the information required for all segments of the various mission types.

USER*, HEL

(3) Time Line Analysis

This task will involve placing the detailed information requirements derived in Task 2 in the time domain across the AAH mission segments. (The AAH contractor has been tasked to provide this information to the PMO by 7 Feb 78.)

PMO*, HEL, USAARL

(4) Information Conflict Identification

From Task 2 and 3, conflicts which exist in terms of the amount or types of information required at one time will be identified. These conflicts could arise from the aviator's inability to handle the amount of information, the fact that provisions cannot be made for simultaneous information and/or presentation of all the information resulting in too much clutter.

USER*, HEL, PMO, AVIONICS

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*Responsible activity.

(5) Trade/Off Analysis

The separate information requirements, identified in Step 4 which are in conflict, will be evaluated in terms of whether they represent essential and/or sufficient data necessary for the aviator to accomplish the task. Additionally, the other information bits over the corresponding specified time periods will be reviewed relative to their criticality. (From this foundation, the final information requirements will be derived.)

HEL*, PMO, AVIONICS, NVL, USAARL, USER

(6) Modes of Display

From the preceding 5 tasks, a determination will be made as to whether or not there exists a logical commonality of information requirements across mission segments so that the requirements can be grouped. A grouping, for example, might include the modes of enroute, hover, bob-up, etc. If modes of displayed information are established, a determination will also be made concerning the automatic or manual selectivity.

AVIONICS*, USER, HEL, PMO, NVL

(7) Criteria for Evaluation

This task will yield criteria and/or methods, both analytical and/or pragmatic (performance related), which can be employed to evaluate the AAH E/O displays.

HEL*, PMO, USAARL, NVL, USER, AVIONICS

These first seven steps (Phase I) represent the analytical portion of the plan with a tentative completion date of April 1978 as a goal.

PHASE II. Symbology Determination and Validation Phase Steps 8 - 13

(8) Sensor and Software Definition

Based on the preceding 7 tasks, a decision will be made whether the AAH has the necessary sensors, software, and computing capability to provide the required information. Additionally, any problems which might exist in interfacing the sensor signals with the symbology generator will be identified.

AVIONICS*, NVL, PMO

(9) Symbology Definition

As a result of the previous steps, candidate sets of symbology will be proposed to meet the established information requirements established.

HEL*, AVIONICS, USER, USAARL

(10) Simulation

The candidate sets of symbology provided by Step 9 will be flown in simulation. This task will dynamically evaluate the symbology. Their effectiveness and acceptability for performing the AAH mission will be established.

AVIONICS*, HEL, PMO, USAARL

(11) Flight Symbology Selection

From the results of Step 10, the best candidate symbology set(s) with desirable modification will be selected for incorporation into flight test.

HEL*, AVIONICS, USER

(12) Flight Test

The flight tests will employ the evolved set(s) of symbology in the flight test environment to realistically evaluate and further refine their utility and effectiveness.

AVIONICS*, HEL, NVL, USAARL, USER, PMO

(13) Recommendations for Standardization

The data and findings from the preceding, sequential steps will be coordinated and formulated into final recommendations regarding standardization of symbologies relative to E/O displays for helicopter applications.

AVRADCOM*, HEL, PMO, USER, USAARL, NVL, AVIONICS

7. SUMMARY

The purpose of this symbology plan and its corresponding working group is to:

(1) Establish the current composite status of helicopter E/O symbology.

(2) Determine the general and specific symbolic requirements for the various aircraft systems and missions.

(3) Formulate requirements into investigative efforts, within existing capabilities to convert information needs into actual symbology and formats.

(4) Apply and interpolate these symbols and formats into recommendations regarding a general E/O standard and specific aircraft systems.

(5) Figure 1A depicts the projected schedule of symbology activities.

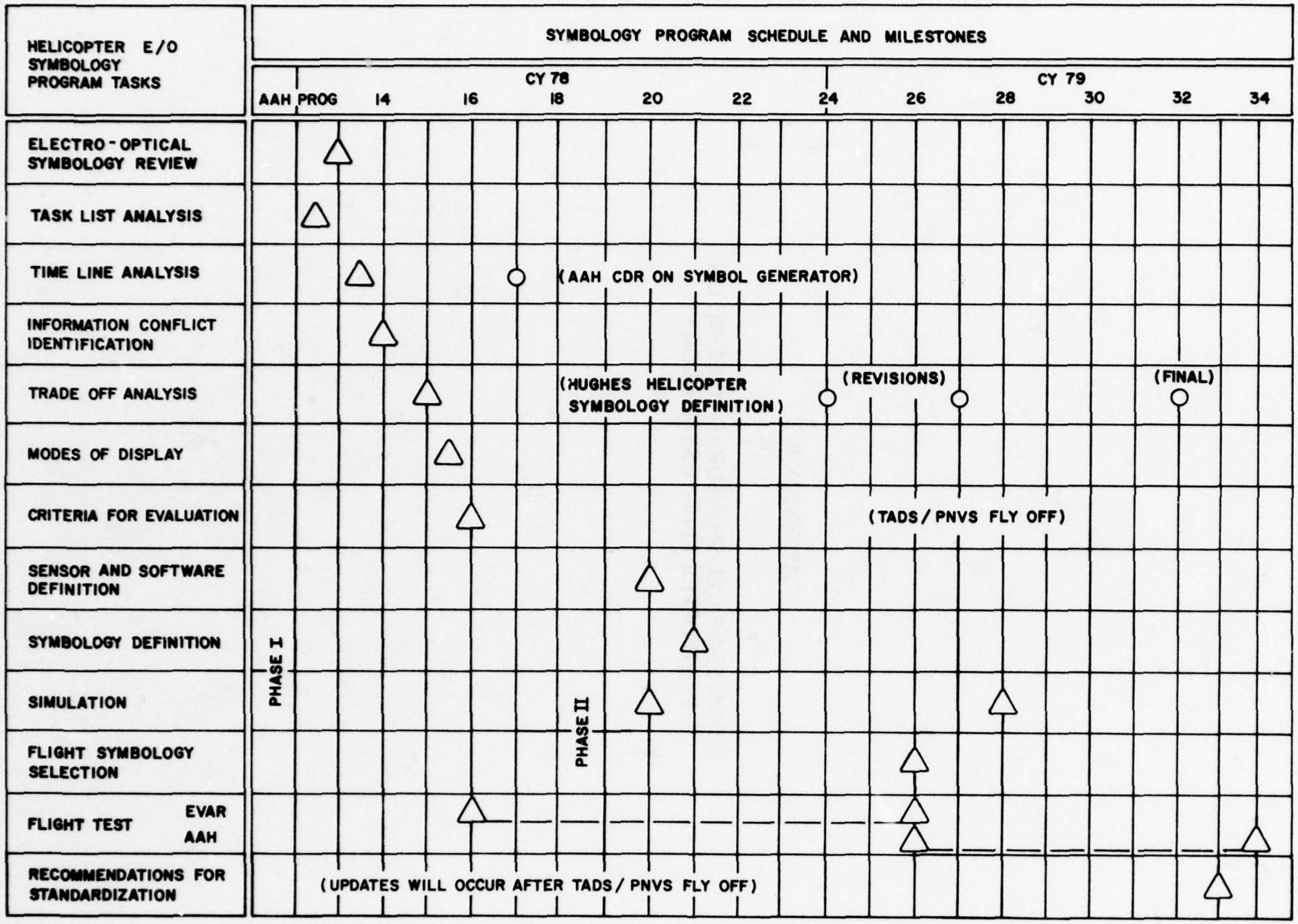

Figure 1A. Projected schedule of symbology activities.

APPENDIX B

MINUTES OF HEL-SPONSORED MEETING ON
HELICOPTER FLIGHT SYMBOLOGY

MINUTES OF HEL-SPONSORED MEETING ON

HELICOPTER FLIGHT SYMBOLOGY

The meeting was opened on 11 Oct 1977, at HEL, APG,MD, by Mr. Clarence A. Fry who welcomed everyone to HEL on behalf of the Director. The chair was then turned over to Mr.Murray Foster (HEL). Each attendee was then asked for a brief self-introduction.

A presentation was then made by Ms. Patricia Williams (HEL) on the Joint Tactical Information Distribution System (JTIDS) program. JTIDS is a tri-Service effort to standardize electro-optical symbology. USAHEL is the Army's representative on this panel. Requests for information and comments on symbology standardization were sent to major users and commodity commands. Two comments predominated: symbology should be simple and consistent. Ms. Williams showed examples of needless inconsistencies among various Army systems. Her objectives are to: (1) provide symbology for new systems that have none, (2) identify inconsistencies and problems in current systems, (3) recommend changes to correct these problems and inconsistencies, and (4) incorporate these changes into a revision of MIL-STD-884C or into a new Military Standard.

Next, Mr. William DeBellis (HEL) presented some examples of the proliferation and variety of flight symbology that has been developed. Many different ways to present the same information were shown to illustrate the lack of coordinated effort in this area of aviation. This was followed by a demonstration of the GAT-IIH flight simulator and electro-optical display system.

Mr. Foster then presented an information matrix which he hoped to fill in with information requirements for various mission segments. In addition, data gaps were to be identified and responsibility for filling these gaps assigned. Mr. Tsoubanos (Avionics Lab) suggested using the PIDS information requirements as a base from which to work.

Mr. Pershing Sun (Avionics Lab) then gave a presentation of flight control symbology being developed by ECOM. This system uses 5 modes. In the first four modes, the periphery information is the same: analog airspeed, analog heading, radar altitude, rate of climb and torque. Cruise mode adds an aircraft symbol and a circle to show line of sensor sight. Transition mode uses a center circle with velocity vector and a second smaller circle shows acceleration. The hover mode magnifies the scale of

the velocity vector. In the bob-up mode a box shows the original position. The navigation mode eliminates the radar altitude and adds course, map display, and field-of-view. A filmed simulation of this symbology was then shown. The ECOM symbology program has identified the need to present aircraft position, velocity, and acceleration to the pilot for positive control.

Mr. Buckler (HEL) then presented some experimental work being done on the Radar Threat Warning Receiver (AN-APR 39/V2) symbology. This provided the meeting with an example of how such problems can be attacked in a systematic manner. Three critical issues were raised: (1)how many different symbols can be used effectively, (2)how many symbols can be portrayed on a display at a single time without hindering performance, and (3) what types of symbols are best - alphanumeric or graphics?

CW2 Dyer, who has had extensive flight experience using night vision systems, emphasized the critical need for symbology if the currently programmed night vision systems (TADS & PNVS) are to show a significant improvement over night vision goggles. He also reiterated the need for simplicity, ease of interpretation and consistency in the symbology and symbol formats.

Mr. Foster then began a discussion of the information matrix presented earlier. There was general disagreement on mission requirements. To resolve this, a video tape on air cavalry operations was shown. After additional discussion, it was agreed that CPT Lovelace should be prepared to present the user position on information requirements at the next meeting. Also, Mr. Tsoubanos was asked to be prepared to present the symbology currently proposed by Hughes for the AAH. The meeting was then adjourned for the day.

The meeting began on 12 Oct 77, with Mr. Tsoubanos' presentation of AAH symbology. Many problems and questions were raised by the group, such as: the need for glideslope and steering in the EADI; scaling of the velocity vector; whether the attitude bar should be tied to the sensor or to the line of sight; digital heading and airspeed; whether indicators should be placed at the top rather than at the bottom.

CPT Lovelace then presented user definitions of minimum information requirements. He identified four mission maneuver segments:

1. Hover IGE - pilot requires torque, power, radar altitude, attitude,sensor/aircraft axes; copilot needs communications and "housekeeping" functions.

2. Take-off/Transition - pilot needs airspeed added; copilot need navigation.

3. Enroute/Cruise - same as above.

4. Hover OGE - pilot needs communications added to the hover symbology which include position, velocity, and acceleration; copilot needs armament information.

CPT Lovelace identified four issues which the user feels are critical. Symbology should: (1) be simple, (2) be consistent, (3) maximize the information transferred, and (4) provide the growth potential for presentation of additional information from future sensor systems. He suggested that the sensors and displays are the responsibility of the Avionics Lab while symbology and information transfer are the responsibility of HEL. He supported a coordinated effort between these two organizations.

Mr. Jackson (AVRADCOM) suggested that coordination among all interested organizations should be focused through AVRADCOM. It was agreed that Mr. Tom Metzler should be asked to act as Program Coordinator.

Mr. Fickling (AVRADCOM) pointed out that April 1978, was a deadline for making inputs to the AAH program. It was agreed that an extended research effort would be impossible in such a short timeframe. Mr. Sun suggested that the ECOM symbology be used as a baseline to facilitate this effort.

CPT Krueger noted that the Hughes proposals presented earlier were four months old. He suggested that the group obtain a more recent and complete proposal from Hughes. The group agreed that this was a necessary next step.

The final presentation of the day was made by Dr. Robert Wright of the Ames Research Center. He presented a summary of facilities that are available on a limited basis at Ames. Dr. Wright also indicated that there might be some limited manpower efforts which could be applied to near-term symbology programs.

Before the meeting was adjourned the group arrived at a consensus on seven items:

1. The last proposed symbology from Hughes is inadequate because it is:

a. inconsistent

b. too complex

c. transfers information inadequately

d. does not show room for growth without adverse impact

2. AAH PMO should be asked to arrange a meeting between Hughes and representatives of this group - probably Mr. Tsoubanos and an HEL member.

3. Next meeting of this group will be held on Nov 15-16 at the Avionics Lab.

4. Mr. Tsoubanos will present the up-to-date Hughes symbology proposals at that meeting.

5. Mr. Tom Metzler and Mr. Bob Fickling will be AVRADCOM focal points for symbology.

6. Symbology should be standardized to the maximum extent possible among all Army helicopters.

7. User representatives will present formal definitions of functions that must be represented by symbology.

HELICOPTER FLIGHT SYMBOLOGY

MEETING

11 - 12 October 1977

MARK HOFMANN	USAHEL Rep, AVRADCOM St. Louis, MO 63166
HAROLD PIERCE	TSM-ASH Fort Rucker, AL
GEORGE BERGERON	USAFAS Fort Sill, OK
CHARLES CROWELY	TSM-AH Ft. Rucker, AL
H.E. LOVELACE	DCD Ft. Rucker, AL
GERALD P. KRUEGER	USAARL Ft. Rucker, AL
DR. ROBERT WRIGHT	Ames Rsch Center Moffett Field, CA
HARRY STOWELL	USAHEL Aberdeen Proving Ground,MD
PATRICIA WILLIAMS	USAHEL Aberdeen Proving Ground,MD
MURRAY FOSTER	USAHEL Aberdeen Proving Ground,MD
RANDY DYER	155th Aviation Co. CDED Fort Ord, CA
ANDREW BUCKLER	USAHEL Aberdeen Proving Ground,MD

(Continued)

WILLIAM DEBELLIS	USAHEL Aberdeen Proving Ground,MD
CLARENCE FRY	USAHEL Aberdeen Proving Ground,MD
DWIGHT NICHOLS	USAHEL DET, MIRADCOM DRXHE-MI Redstone Arsenal, AL
BOB FICKLING	AVRADCOM - HFE St. Louis, MO
MELVIN JACKSON	AVRADCOM St. Louis, MO
CHRIS TSOUBANOS	Avionics Lab ATTN: DAVAA-F Fort Monmouth, NJ
PERSHING SUN	Avionics Lab ATTN: DRSEL-VL-D Fort Monmouth, NJ
TIM NEEL	NVL Fort Belvoir, VA

(Concluded)

APPENDIX C

TYPICAL ATTACK HELICOPTER MISSION TASK ANALYSIS

TYPICAL AH-64 ATTACK HELICOPTER MISSION DAY/NIGHT

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Before take-off										
Pre-flight AH-64 aircraft	X									Check List
Pre-flight AH-64 weapons systems		X						Hellfire 30 mm 2.75"	TADS	Check List
[illegible]sert missile code from CEOI		X								SOP
Key KY 58 Secure system	X									SOP
Receive Mission	X	X								
Mission Planning	X	X								SOP
Engage APU (Aux Pwr Unit)	X									APU control unit
Perform electrical system check	X									Check List /AC/DC/Gen Gen 2.
Perform navigation system check	X	X		All	All					Check List
Perform weapons systems check	X	X						Hellfire 30 mm 2.75"	Both	Check List BITE
Perform fuel system check	X									Fuel Qty, Fwd, Aft, Total.
Perform communication system check	X	X				VHF, UHF, FM 1 & 2.				SOP
Perform flight controls check	X	X								Check List
Perform lights check	X	X								Check List
Perform SCAS check	X									A/C Stabil Equipment

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPONS SYSTEMS	TADS/ PNVS	OTHER/ MISC
Perform De-Ice check	X									Check List
Perform ECU system check	X									Check List Cabin Air control.
Perform Pilot heat check	X									Check List Pilot heat/ temp
Perform cockpit console check	X	X								Check List
Perform engine check/Disengage rotor Brake.	X	X					All-Cross-check			Check List
Perform flight instrument check	X	X		All						Check List
Perform starting engine procedures (Engine 1 & 2)	X						All-Cross-check			Check List
Perform engines run-up	X						All-Cross-check			Check List
APU off	X									APU Cont.
Perform before take-off check	X	X								Check List
Arm Weapons systems	X	X						Hellfire 30 mm 2.75"		As approp; Master Arm Cir breaker
<u>Perform take-off</u>						Monitor- VHF, UHF, FM 1 & 2.				
Perform Go-No-Go procedures	X			Scan	Scan		Cross-check			
Perform engine health check	X						Check- TGT, Temp, Eng RPM			
Perform take-off to hover	X			Scan	Scan	Monitor	Scan			

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Perform take-off from hover	X			Scan	Scan	Monitor	Scan			
Perform take-off from ground	X			Scan	Scan	Monitor	Scan			
Perform running take-off	X			Scan	Scan	Monitor	Scan			
Perform maximum load take-off	X			Scan	Scan	Monitor	Scan			
Perform slope take-off/landing	X			Scan	Scan	Monitor	Scan			
Perform take-off abort	X						Cross-check			Check emerg condition; check list emerg. proc.
Perform in-ground effect hover	X			Scan	Scan	Monitor	Scan			
Perform out-of-ground effect hover	X			Scan	Scan	Monitor	Scan			
Perform flight instrument check	X	X		Cross-check	Scan	Monitor	Scan			Check List
Perform engine instrument check	X	X		Scan	Scan	Monitor	Cross-check			Check List
Perform flight controls check	X			Scan	Scan	Monitor	Scan			Check List
Compute fuel burn-out	X	X				Monitor				Fuel qty, /aft, total
Recognize aircraft emergency condition	X	X				Monitor				Check List-emerg. proc.
Enroute to mission/Attack HEL Team										
Receive holding area briefing from scout	X	X		Scan	Scan	UHF	Scan			
Manuever low-level to holding area	X			Scan	Scan	Monitor	Scan			

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Navigate to holding area with onboard nav. equipment		X		Scan	Cross-check	Monitor				
Navigate to holding area with maps		X		Scan	Scan	Monitor				
Manuever aircraft in holding area	X			Scan	Scan	Monitor	Scan	Before-attk checks		
Shut-down aircraft as required	X					Monitor	Cross-check			APU on, rotor Brake engag.
<u>Prior to attack</u>										
Prepare for attack mission	X	X				Monitor UHF, VHF, FM 1 & 2.				
Receive attack mission briefing from scout	X	X				Monitor				
Engine starting procedures if reqd	X					Monitor	Cross-check			Rotor brake disengage, APU off
Conduct map reconnaissance to battle positions/firing positions	X	X				Monitor		Mission-ready		
Manuever out of holding area	X			Scan	Scan	Monitor	Scan			
Manuever contour enroute to battle position	X			Scan	Scan	Monitor	Cross-check			
Navigate during contour flight		X		Scan	Scan-all+ Heading Ind.	Monitor	Scan			
Transition to NOE flight	X					Monitor				
Monitor emergency warning light system during NOE flight	X	X		(Subconscious awareness as to possible emergency conditions; primary tasks of pilot will be that of flying aircraft, heads-up and reacting to outside conditions; co-pilot/ gunner will be navigating through use of map/onboard nav. equip)						

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Navigate during NOE flight		X		Scan	Heading Ind+ onboard nav equip	Monitor				
Provide self-defense security enroute	X					Monitor		30 mm	TADS	
Maintain contact with scout and other members of Attk HEL Team	X	X				VHF, UHF, FM 1 & 2.				
Monitor communications with ground commander	X	X				FM 1/FM 2				
Monitor coordination for artillery fire support	X	X				FM 1/FM 2				
Operate Aircraft survivability equipment	X	X				Monitor				RWR/ASE
Occupy Battle Positions	X	X		Scan	Scan	Monitor	Scan	Hellfire, 30 mm, 2.75 checks		
Receive attack mission	X	X				As approp				
Manuever to firing position	X					Monitor				
Receive initial handoff from scout		X				As approp				
Prioritize targets		X				Monitor				
Select weapon system (Hellfire laser-scout designate)		X				Monitor		Hellfire-laser	TADS	RWR
Code missile to be fired		X				Monitor		HF-laser	TADS	RWR
Hover out of ground effect	X				Heading Ind	Monitor	Scan			

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
During the attack										
Acquire nearest threat		X				Monitor		HF-laser	TADS	
Engage/fire missle (ZSU-23-4, 3000 meters) Transmit missle launch count-down		X				Monitor/ Communicate		HF-laser	TADS	
Remask	X					Monitor	Scan			RWR-ASE
Receive damage assessment from scout	X	X				VHF-UHF				
Unmask	X				Heading Ind	Monitor				
Acquire secondary target		X				Monitor		Hellfire-laser	TADS	
Select weapon system (Hellfire laser-autonomous)		X				Monitor		HF-laser	TADS	
Engage/fire missile (T-72, 3500 meters)		X				Monitor		HF-laser	TADS	
Continue to designate until target destroyed		X				Monitor		HF-laser	TADS	
Unmasking/Remask	X			Scan	Scan	Monitor	Scan			RWR-ASE
Acquire third target	X					Monitor		30 mm		RWR-ASE
Manuever/engage target (BRDM-2, 2500 meters)	X					Monitor		30 mm		RWR-ASE
Manuever to alternate firing position 2, directed by scout	X					UHF-VHF				RWR-ASE
Receive target handoff from scout		X				UHF-VHF				
Select weapon system (Hellfire RF/IR)		X				Monitor		HF-laser	TADS	

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER MISC
Unmask	X			Scan	Scan	Monitor	Scan			RWR-ASE
Acquire fourth target		X				Monitor		Hellfire- RF/IR	TADS	
Engage /fire missile (ZSU-23-4, 2500 meters)		X				Monitor		HF-RF/IR	TADS	
Remask	X					Monitor				RWR-ASE
Receive damage assessment from scout	X	X		Scan	Scan	UHF-VHF	Scan			RWR-ASE
React to enemy radar scan	X					Monitor				RWR-ASE
React to enemy radar lock-on	X					Monitor				RWR-ASE
Take evasive manuever actions	X					Monitor				RWR-ASE
Manuever to alternate firing position 3, directed by scout	X					UHF-VHF				RWR-ASE
React to sighting of enemy BMP'S	X					Monitor		30 mm	TADS	RWR-ASE
Select weapon system	X					Monitor		30 mm	TADS	RWR-ASE
Engage enemy vehicles (BMP's 2200m) (fifth target)	X					Monitor		30 mm		RWR-ASE
Take evasive action from enemy engagement	X					Monitor				RWR-ASE
React to additional enemy targets reported by scout		X				UHF-VHF		30 mm	TADS	
Engage enemy vehicles (BMP's 1900 m) (sixth target)		X				Monitor		30 mm	TADS	
React to enemy artillery	X					Monitor				RWR-ASE

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Receive briefing on available battle position	X	X		Scan	Scan	UHF-VHF	Scan			RWR-ASE
Manuever to new Battle position	X					Monitor				RWR-ASE
Manuever NOE into firing position 1	X					Monitor				RWR-ASE
Receive initial target from scout	X	X				UHF-VHF				RWR-ASE
Prioritize targets		X				Monitor				
Select weapon system (Hellfire laser-autonomous)		X				Monitor		Hellfire-laser	TADS	
Unmask-manuever as necessary	X					Monitor				RWR-ASE
Acquire seventh target		X				Monitor			TADS	
Engage/fire missile (T-72, 4210 meters)		X				Monitor		Hellfire-laser	TADS	
Continue to designate until target destroyed		X				Monitor		HF-laser	TADS	
Assess damage		X				Monitor			TADS	
Remask	X			Scan	Scan	Monitor				RWR-ASE
Receive update from scout on changing battlefield situation	X	X		Scan	Scan	UHF-VHF				RWR-ASE
Recognize weapon system malfunction	X	X				Monitor		HF, 30 mm. 2.75		
Take corrective action on weapon system malfunction	X	X				Monitor		As approp.		

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Establish communications with ground scout		X				FM 1				
Use CEOI	X					Monitor				RWR-ASE
Receive and reprogram new missle code from ground scout		X				FM 1				
Receive target handoff from ground scout		X				FM 1			TADS	
Select missile seeker (HF-laser, ground scout designate)		X				Monitor		Hellfire-laser	TADS	
Unmask	X					Monitor				RWR-ASE
Acquire eighth target		X				Monitor		HF-laser	TADS	
Engage/fire missile (ZSU-24-3, 4400 meters) Transmit missile launch count-down		X				Monitor/ Communicate		HF-laser	TADS	
Remask, manuever into alt firing position 2	X			Scan	Scan	Monitor				RWR-ASE
Receive damage assessment from ground scout	X	X		Scan	Scan	FM 1	Scan			RWR-ASE
Monitor air scout commo with AF FAC (in helicopter)	X	X				UHF-VHF				RWR-ASE
Receive target handoff from scout	X	X				UHF				
Select 2.75 rockets from wing stores management	X					Monitor		2.75" rockets	TADS	
Unmask	X					Monitor				
Determine range to target-autonomous		X				Monitor			TADS	
Receive range to target from scout	X					UHF				

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER MISC
Employ remote fuze setting for rockets	X					Monitor		2.75" rockets	TADS	RWR-ASE
Unmask or fire engagement indirect (if range is given) Suppression of ninth target prior to CAS/A-10 attack/(Enemy ADA, SA-9, 5900 meters	X					Monitor		2.75" rockets HE & Smoke	TADS	RWR-ASE
Receive damage assessment from scout	X	X		Scan	Scan	UHF-VHF				RWR-ASE
Scout coordinates shifting of Fire support artillery prior to A-10 Attk	X	X				Monitor FM 2				RWR-ASE
Scout coordinates with FAC during A-10 attack	X	X				Monitor UHF-VHF				RWR-ASE
Provide overwatch and suppressive fire during attack	X	X				Monitor		30 mm	TADS	RWR-ASE
Monitor scout and FAC battle damage assessment	X	X				UHF-VHF				RWR-ASE
Monitor scout coordination with ground commander for fire support	X	X		Scan	Scan	FM-1	Scan			RWR-ASE
Monitor spot reports from scout to ground commander	X	X		Scan	Scan	FM-1	Scan			RWR-ASE
Receive handoff from air scout on additional moving enemy tanks		X				UHF			TADS	
Pre-select three laser codes		X				Monitor		HF-laser	TADS	
Coordinate for ground and air scout designation		X				FM-1-UHF		HF-laser	TADS	
Unmask	X					Monitor				RWR-ASE

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Acquire tenth, eleventh, and twelfth targets		X				Monitor		HF-laser	TADS	
Engage/fire two HF missiles (First designation by ground scout, second by air scout) (two T72's 3800 m) Transmit missile launch count-downs		X				FM-1/UHF Communicate		HF-laser	TADS	
Remask, manuever into alternate firing position 3	X			Scan	Scan	Monitor				RWR-ASE
Unmask, re-acquire and fire remaining laser HF (autonomous) (T-72, 3950 meters)		X				Monitor		HF-laser	TADS	
Continue to designate until target is destroyed		X				Monitor		HF-laser	TADS	
Assess damage		X				Monitor			TADS	
Remask	X					Monitor				RWR-ASE
Receive damage assessments from ground and air scout on ripple fire of to Hellfires	X	X				FM-1-UHF				RWR-ASE
Receive replacement on station of another attack HEL team	X	X		Scan	Scan	UHF-VHF	Scan			RWR-ASE
Monitor handoff of battle situation to replacement attack HEL team	X	X				UHF-VHF				RWR-ASE
Perform remaining fuel/ordinance checks	X	X				Monitor				RWR-ASE
Receive end of mission/manuever out of battle position	X	X				FM/UHF/VHF				RWR-ASE
Receive report of enemy reconnaissance activity during egress from scout	X	X				UHF			TADS	RWR-ASE

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIO	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Following the attack										
Recheck of remaining ordinance	X					Monitor		30 mm 2.75"	TADS	RWR-ASE
Manuever NOE enroute to FARRP	X			Scan	Scan	Monitor	Scan			RWR-ASE
Navigate NOE enroute to FARRP		X				Monitor				
Receive handoff from scout-reports receiving fire from enemy recon elements	X					UHF		30 mm	TADS	
Select weapon system	X					Monitor		30 mm	TADS	
Manuever/acquire and engage enemy vehicles (BRDM's, 2600 meters)	X					Monitor		30 mm	TADS	RWR-ASE
Assess and report damage	X	X				UHF			TADS	RWR-ASE
Manuever NOE enroute to FARRP	X			Scan	Scan	Monitor	Scan			RWR-ASE
Navigate enroute to FARRP		X				Monitor				
Monitor scout SITREP to commander	X	X				UHF				RWR-ASE
Transition to contour flight	X			Scan	Scan	Monitor	Scan			RWR-ASE
Navigate during contour flight		X				Monitor				
Place weapons systems in OFF position	X	X				Monitor		ALL		
Manuever into FARRP	X					Monitor				RWR-ASE
Land at refuel/rearm point	X					Monitor				
Coordinate for next combat mission mix load of fuel and ordinance	X	X				Monitor				
Perform engine shut-down of right, #2 engine	X					Monitor	Cross-check			Check List

(Continued)

TASKS	PILOT	GUNNER	LOCATION	FLIGHT INSTRUMENTS	NAVIGATION INSTRUMENTS	COMMO/ RADIOS	ENGINE INSTRUMENTS	WEAPON SYSTEMS	TADS/ PNVS	OTHER/ MISC
Engage rotor brake	X					Monitor	Cross-check	OFF		Check list
Supervise simultaeous HOT Refuel/ Rearming of AH-64	X	X						OFF		
RECEIVE BRIEFING ON NEXT MISSION	X	X								

(Concluded)

APPENDIX D

PNVS FLIGHT SYMBOLOGY TRADE-OFF ANALYSIS

PNVS FLIGHT SYMBOLOGY TRADE-OFF ANALYSIS

I. General Considerations

1. Symbol Placement

Spacing Toward Outer Edges - keeps center portion of video image clear of obscuration.

Grouping Toward Center - (1)reduces magnitude of eye scan which could be significant in a $30^{o} \times 40^{o}$ FOV. (2)avoids problem of distortion of symbols near outer edges.

2. Symbol Sizing

Larger Symbols - increase legibility

Smaller Symbols - reduce obscuration of video image.

3. Scaling - insure that scale gains are compatible with control input and aircraft response rates.

4. Daytime Symbology -

Additional symbology - increase the information available to the pilot without having to come back into the cockpit.

Reduced Symbology - reduces obscuration of pilot's view of the real-world which provides his primary control cues.

5. PNVS-EADI Compatibility

Total Compatibility - is not possible nor desirable due to differences in displayed information and intended use.

Maximum Compatibility - is desirable to insure that the same information will be portrayed in the same manner on both displays to avoid any confusion between the two.

II. Specific Considerations

1. Radar Altimeter

Analog - (1)provides trend information as to rate and direction of change. (2)may eliminate the need for a vertical velocity indication.

Digital - lessens obscuration of video image.

2. Airspeed Indicator

Analog - provides trend information as to rate and direction of change.

Digital - (1)lessens obscuration of video image. (2)may be sufficient if video provides enough cues for trend information.

3. Vertical Velocity Indicator

Pro - would give additional altitude trend information.

Con - (1)same information can be gained by an analog altimeter; (2)adds clutter and obscures the video image.

4. Torque Indicator (power status)

Continuous - information is always available to the pilot without bringing his head back into the cockpit.

As required - that is, the information is displayed only when at or approaching some limit; reduces clutter and obscuration of the video image.

5. Attitude Indicator

Tied to Aircraft LOS - reduces clutter and obscuration at the center of the display.

Tied to Center of Display - pilot does not have to "chase" his attitude all over his FOV.

6. PNVS Gimbal Limits Display

Pro - provides additional information to help the pilot locate the cued LOS.

Cons - (1)may not be necessary if cueing dots are used or if cued LOS is pegged to the edge of the screen; (2)clutters and obscures a critical portion of the video image.

7. Hover Mode

Hover Position Only - keeps display simple and reduces clutter and obscuration of the video image.

Hover Position with Velocity and Acceleration - provides pilot with additional information required to maintain a precise hover.

Retain Airspeed Indicator - (1)provides redundant velocity cues; (2)may be required if velocity and acceleration vectors are not provided.

Delete Airspeed Indicator - (1)not necessary if velocity and acceleration vectors are provided; (2)reduces clutter and obscuration of the video image.

8. Number of flight modes

Added Modes - such as transition and bob-up; provide greater flexibility and help to insure that the pilot receives all the information needed in all phases of flight.

Fewer Modes - (1)helps to keep the display simple and easy to use and understand; (2)may provide sufficient information for controlled flight.